Mr. Youngberg: heavier, has more nutrients and has a better germination pattern than seed produced on infertile soils. Now it doesn't necessarily always hold as in very fertile soils versus medium soil fertility, there is generally not much difference, but when dealing with very infertile soils versus the rest of the range of fertility, there has definitely been shown to be a factor that is involved in the quality of the seed produced on those sites.

I would say that I am a newcomer to the field out here, but probably one of the few natives of the State of Washington that has been working in Washington, at least of the ones I have come across so far.

MAINTENANCE OF NURSERY SOIL FERTILITY

by
Chet Youngberg

* *

The need for intensive control of soil fertility factors is greater in forest nursery practice than in almost any other branch of plant production. Nursery soils are subject to an exceptionally heavy drain of nutrients because harvesting of the densely grown crop removes the entire plant and portions of the soil. Leaching caused by irrigation and in this region by heavy winter precipitation is also an important cause of depletion of nutrients. The deficiency of plant nutrients is corrected by use of animal and green manures, composts, direct application of fertilizer salts prior to seeding and liquid fertilizer applications. The success of these treatments is dependent upon the maintenance of a reasonably high exchange or nutrient holding capacity in the soil, proper adjustment of soil reaction and provision of an environment suitable for mycorrhizal fungi and other desirable organisms. This in turn is often complicated by our choice of insecticides fungicides and weed killers. It is not difficult to visualize the delicately balanced environment that modern technique has designed for the production of nursery stock. The quality of this stock cannot be evaluated on the usual basis of size and amount of dry matter produced, but only by its ability to survive in the struggle against adverse environmental influences, parasitic organisms and browsing animals.

The problem we are faced with, then, is how to provide a favorable environment in which seedlings of satisfactory physiological quality may be produced. From the standpoint of soil fertility factors this environment should approach that found where any given species is naturally attaining optimum growth. At one time some European foresters believed that seedlings to be planted on infertile sites should be grown under similar fertility conditions in the nursery. This proved to be a fallacy when starved and unbalanced seedlings failed to survive when planted in the field. On the other hand, equally disastrous results have been experienced with the use of heavily fertilized stock.

The question naturally arises as to what is a desirable level of soil fertility for Douglas fir seedlings. At your meeting last year Dr. Wheeting stated that "the requirements of trees for nutrients can be guessed at from the analyses of their ash." Actually this is better than a guess and is a step in the right direction. However, we can go a step farther by investigating the fertility status of soils supporting productive forest stands. This is no new approach, but was advocated by Hilgard, an early American soil scientist, and has been used successfully

in other regions for determining fertility standards for the production of tree seedlings. The majority of the nutrient elements taken up by trees go into the leaves. In the case of coniferous trees a portion of the leaf litter is returned to the soil annually. This litter undergoes decomposition being acted upon by soil organisms and in time organic matter or humus is formed. Portions of the nutrient elements remain in an organic form, a part becomes mineralized. In either case they may be taken up by the tree again and in time returned to the soil in leaf litter. An equilibrium generally dependent upon climate is eventually reached at which time a system of revolving fertility is in evidence. The balance or ratio of nutrient elements is quite constant once this equilibrium is attained, although the level may vary somewhat.

Using a method successfully employed for other species, fertility standards have been determined for Douglas fir. The surface layers - i.e., the zone of maximum feeding activity, of soils supporting productive stands of Douglas fir were collected for analyses. The soils were derived from glacial, sedimentary and volcanic parent materials. Stands in the Coastal and Cascade regions of Oregon and Washington were sampled. The soil samples were pre-treated and analyzed according to standard methods adopted by the Forest Soils Committee for the Douglas Fir Region.

The standards based on the analyses of these samples are as follows:

Soil reaction pH range	Total N pct.	Approx. Level Avail N lbs./acre	Avail. P_2O_5	Avail. K_2O	Exch. Ca	Exch. Mg
			Pounds per Acre			
4.8 - 5.8	0.200	40	80	200	2000	450

As yet we have no tests of these standards in greenhouse or nursery trials. However, some are in progress.* Greenhouse and nursery trials plus practical reforestation experience have proven standards derived by similar methods in the Lake States and other regions.

*Vail and Wind River Experimental Plantations.

Soil Reaction

Soil reaction or pH is known to play an important role in the availability of nutrients to agricultural crop plants. Acid soils are often low in available phosphorus and potassium. The presence of myccorhizal fungi in symbiosis with tree roots, however, may well account for the ability of trees to extract nutrients from acid soils. At any rate a pH range of 4.8 - 5.8 is satisfactory for Douglas fir. An acid pH is also less favorable for the development of damping-off fungi. pH 5.2 - 5.3 good point to maintain.

Organic Matter and Nitrogen

The maintenance of a favorable organic matter-nitrogen economy in the soil is, in all likelihood, the most practical means of providing a favorable soil fertility environment for tree seedlings. The growth of seedlings in a soil containing unabsorbed fertilizer salts is different from the growth in a medium in which the salts have become incorporated into organic matter by means of chemical and biological reactions. Most coniferous forest soils test extremely low in available nitrogen, particularly in the nitrate form, even if analyzed during the

period of maximum biological activity. Conifers are able to utilize nitrogen in the form of ammonia and even in more complex forms such as amino acids. By maintaining an ample supply of soil organic matter the nitrogen supply is generally adequate. An organic matter content of about 7 to 9 percent appears to be satisfactory for this purpose. In addition to supplying the necessary nitrogen, organic matter also contains phosphorus, potassium, calcium, magnesium, iron, and sulfur, as well as the essential minor elements. An adequate supply of soil organic matter is also essential for the development of mycorrhizal fungi and other soil organisms. Not advocating organic farming.

Phosphorous

The phosphorus nutrition of coniferous seedlings is known to be related to the activity of mycorrhizal fungi. The exact relationship in Douglas fir is not yet established, but it seems unlikely that it would be radically different than in some of the eastern and European coniferous species. 80 pounds per acre of available phosphoric acid (P_2O_5) is essential for optimum growth conditions.

Potassium

Potassium is removed from the soil by feeding roots and by leaching faster than it is replenished by the normal weathering of minerals. Therefore, it is usually necessary to add potash fertilizers. 200 pounds per acre of available potash (K_2O) is required for the normal growth and hardening-off processes.

Calcium and Magnesium

These two essential elements are usually present in the standard fertilizers used in nursery practice and an adequate supply is thus maintained. 2000 pounds per acre of exchangeable calcium, and 450 pounds per acre of available magnesium are desirable levels.

Sufficient sulfur is also supplied in the fertilizers used. Iron and the minor elements are usually present in adequate amounts in productive soils.

It should be pointed out that the ratio of available nitrogen to phosphoric acid to potash is 1-2-5. Actually the balance or ratio of the various elements to each other is of more importance than the amounts of individual elements present. As previously stated, the ratio of nutrients in the surface soils supporting productive forest stands possesses a fairly uniform balance, and validly expresses the requirements for the species present. In the nursery deficiency symptoms are often very obvious if any of the essential elements are in short supply. On the other hand, if the ratio is upset by an oversupply of a nutrient, the normal uptake of other nutrients is altered. This usually results in a change in the normal physiological processes. The changes are internal and are not always evident in the gross morphological characteristics of the seedlings; however, practical experience in other regions, particularly with longleaf pine in the south, has shown that there are marked differences in survival of seedlings of different "physiological grades."

*Vail and Wind River Experimental Plantations.

Methods of Fertility Adjustment and Maintenance

Some of the theoretical aspects have been considered. Now it will be well to consider the practical applications and methods of attaining the desired results. Last year Dr. Wheeting told you that "the replacement of organic material is one of the key points of soil management in nurseries." I heartily endorse this statement. I have visited two state nurseries, and have soil analysis data from one, read Dr. Wheeting's report about the soil management program at the Wind River Nursery and have been told about the program at the Soil Conservation Service Nursery. All four of these nurseries have a system of green manure or soiling crops in practice. The data available from two of these nurseries reveal that a satisfactory level of soil organic matter, i.e., 7 precent or better, has been maintained. I presume that it would be safe to assume that the other two nurseries have a favorable soil organic matter status also; this for the Douglas fir region. Incorporating the commercial fertilizer salts in a green manure crop rather than direct application prior to seeding is a very desirable practice and more nearly approaches natural conditions. It also serves to prevent the accumulation of excess fertilizer salts on the soil surface due to evaporation. Another desirable feature of this program is the presence of a cover on the soil during the period of heavy winter rainfall. This is beneficial from the standpoint of physical properties of soils as well as their fertility status.

The application of nitrogen fertilizer to a non-legume and the inoculation of legume cover crops with nitrogen fixing bacteria will usually amply supply the necessary nitrogen to the seedling crop to follow. It is better to be conservative in the use of nitrogen fertilizers, thus preventing the production of soft succulent seedlings. Nitrogen deficiencies are easily recognized and may be corrected readily by liquid nitrogen applications.

Another method of replacing organic matter is by the addition of materials, such as peat moss or sawdust. In order to obtain results similar to those obtained when plowing under a green manure crop, it is necessary to compost these materials with fertilizer salts for one to two years. It also requires compost pits provided with means for collecting and reapplying drainage water if a satisfactory job is to be achieved.

If a carbon-nitrogen ratio equal to that of a legume is to be obtained, it is necessary to add nitrogen. In the case of Douglas fir sawdust, it would require 200 pounds of 20 percent Ammonium sulfate per ton of dry sawdust. To increase soil organic matter 2 percent would require 20 tons of sawdust (dry weight) and 2 tons of 20 percent Ammonium sulfate.

With nitrogen we have the choice of using nitrogen fixing legumes as a cover crop or adding nitrogen fertilizer to a non-legume cover crop or to composts. With phosphorus and potassium our only choice is to add them in the form of fertilizer. Here again the desirable method is composting or incorporating the fertilizer salts in a green manure crop.

With regards to phosphorus, we have been sold a bill of goods by our agricultural colleagues. Many of the soils in the Douglas fir region are inherently low in phosphorus and in agricultural practices large applications of phosphate fertilizers are required. In some cases the same practices have been carried over into forest nursery management, to the end that in some instances the ratio of phosphorus to the other elements is definitely out of balance. The raising of

agricultural crops, often involving the production of seed or grain, requires larger quantities of phosphorus than does the raising of coniferous seedlings. In addition, myccornizal fungi are known to play an important role in the phosphorus nutrition of coniferous seedlings, making it possible for them to utilize the more difficult available forms of phosphorus. Phosphorus is not as mobile as nitrogen and potassium and is not subject to as great losses by leaching. As a result, it is possible to build up an excess if large applications are made at frequent intervals.

In contrast to phosphorus, the content of available potash in many of the soils in this region is high. This high level is readily maintained in a forest soil by the system of "revolving fertility" that is enhanced by the annual fall of leaf litter. In the nursery, on the other hand, it is subject to rapid depletion and is often in short supply at the critical time i.e., when it is needed to facilitate hardening-off. The only method available to replenish the potash supply at the beginning of a rotation is by application of potash fertilizers, either directly or by incorporation in a cover crop or compost. Potash, like nitrogen, can be easily applied in a liquid form to established seed beds if the need arises.

The necessity for adjusting soil reaction in an established nursery does not often arise. If a soil becomes too acid, and it is desired to increase the pH, it may be readily done by applying agricultural lime. The lime should be added just prior to establishing the cover crop. It is best to avoid applying it just before seeding to coniferous seedlings since the lime favors the development of damping-off and root rotting fungi. Elemental sulfur or aluminum sulfate may be used in a similar manner to lower the pH value.

Thus far in our consideration of soil fertility maintenance we have discussed primarily the nutrient element availability. One of the more important factors affecting nutrient availability is the physical condition of the soil. A soil may test high in available nutrients, but if it is in a poor physical condition the plant has difficulty extracting the nutriends. A well granulated soil provides an optimum soil-air-water environment and enhances maximum root development and nutrient uptake. It is entirely possible that with our intensive cultural practices, particularly the lifting of stock when the soil is wet, that the physical condition of the soil is suffering. It does not require much disturbance when the soil is wet to destroy soil structure. Excessive use of rototillers also tends to destroy soil structure. As a result, crusting on the surface is often apparent during periods of rapid evaporation, and good aeration is not possible.

The maintenance of a high organic matter content plays an all important role in providing good physical condition of the soil. Not only does the organic matter provide the essential cementing agents necessary for the formation of soil aggregates, but it also increases the buffering capacity of the soil, thus preventing rapid changes in soil reaction and the accumulation of toxic concentrations of free fertilizer salts on the soil surface. It is also a necessary energy material for soil organisms, whose activity improves soil structure.

There is much publicity about soil conditioners at the present time. Some of these show promise in improving and maintaining good physical condition, especially on heavier soils. As yet they are only in the experimental stage.

In summarizing these thoughts, we find that the maintenance of a proper ratio or balance of nutrients, or in other words a balanced diet, is essential

for optimum nutritional activity. Secondly, the incorporation of the nutrients into organic matter, and the maintenance of this organic matter at a favorable level provides an environment that most nearly approaches a natural soil-tree root relationship.

Chairman Webster: Don't go away now, Chet. We are going to ask you some questions.

Mr. Stubbs: In connection with controlling soil pH, actually can you do anything on a practical basis on that, on Nursery soil?

Mr. Youngberg: It depends a lot on your soil. You take a light sandy soil, your changes in reaction will be much more rapid than a heavier soil. The reason for that is when you add lime to a soil, you replace hydrogen with calcium, and a sandy soil does not have much of what we call exchange capacity, or a nutrient-holding capacity, and it will only hold so much. The rest of it you put on is there for a certain length of time and eventually is leached out, as the calcium that is held in exchange is eventually replaced by hydrogen again. Leaching takes place, and your soils would become acid again. A heavier clay soil would hold more calcium and hold it for a longer time, and thus your changes aren't as rapid.

Now there again organic matter plays an important role, because your exchange capacity is dependent upon the colloidal capacity of the soil. The capacity of the colloid clay or colloids present to hold onto these various nutrient elements, and calcium being the element that controls pH as against hydrogen, the more calcium you can hold in the soil, the more your pH will remain at a favorable level.

Mr. Stubbs: What I am asking you, can you actually exchange the pH and maintain it? Is it practical?

Mr. Youngberg: Well, it has been done. I don't say it has been done out here, but of course they do it on their agricultural land, and it has been done in forest nurseries in the Lake States, and there of course they have quite sandy soils for the most part, but they have done a pretty good job of maintaining there, applying their lime, and quite often if they use certain types of fertilizers that are high in calcium, that also will cut down the drain on the available calcium that is there in the soil.

Mr. Nagle: They haven't had equally good results in the opposite direction, from high to low.

Mr. Youngberg: You mean from alkaline to acid? Elemental sulphur has been used, and also ammonium sulphate with a certain degree of success, but it is generally not as successful. I think they have also used just plain ordinary sulphuric acid treatment to lower it. You see, all you are doing there is replacing the calcium with hydrogen when you add any acid material. It is the hydrogen that causes the acidity.

Mr. Rindt: Chet, you said something about use of rototillers destroying soil structure. Just how is that done and how serious is it?

Mr. Youngberg: Well, it all depends a lot on the soil. You take a heavy clay soil probably it would do more damage than on a lighter soil. On a sandy soil where you have no soil structure to begin with, there is no difficulty at all, but I think you will find that most of your soil physicists will agree with the statement that the best way to break down the structure of the soil is to use a rototiller excessively.

Mr. Rindt: When you say "break it down...."?

Mr. Youngberg: Well, actually it just beats the soil. The aggregates are just broken down into individual particles, not completely, but to a great extent.

Mr. Rindt: Then what is the net result? Do you get more caking?

Mr. Youngberg: That's right.

Mr. Rindt: More crusting than you would without the rototiller?

Mr. Youngberg: That's right.

Chairman Webster: What do you mean by using a rototiller excessively? Do you mean using it once a year or once every three years?

Mr. Youngberg: Oh no, but there have been cases where rototillers have been used maybe half a dozen or more times within a season and there again it depends quite often on the soil moisture too at the time of use. Any working of the soil when it is wet will puddle the structure. Once a year would not damage the soil if done when soil moisture is favorable.

Mr. McDaniel: Don't you think a lot of the destruction with rototillers is from attempting to work the soil at the wrong time of year. They cautioned us not to work our soil with a rototiller in the fall of the year, but to work the top of our beds three or four inches deep just prior to planting to fluff it for a better seed bed.

Chairman Webster: And that occurs once every three years approximately?

Mr. McDaniel: Well, yes.

Chairman Webster: That is not too often.

Mr. McDaniel: You can work in your cover crop also, the top layer of your cover crop, whereas if you went over it with a disc and harrow, you fellows know that you would drag it out, whereas your rototiller will chew it up, put it in a good condition, and also aid in the decomposition of your soil crops.

Dr. Wright: I would like to make a comment on soil acidification with regard to damping off fungi. Of course, you fellows all understand that the damping off fungi are only active and effective as a rule in the early life, right after germination, less than a month to maybe six weeks, depending on growing conditions. Acidification isn't intended to last for a long time, but just while the seeds are in the seedling stage.

I would like to ask one more question here, and that is in the total nitrogen in the ground did you mean 2/10 percent there?

Mr. Youngberg: That's right.

Dr. Wright: I thought that was awfully small.

Mr. Youngberg: Well, actually it sounds small, but it is a fairly good -- now that is not just the surface, that is the surface seven inches of soil thoroughly mixed, which is about what you would approach if you went out and put a nursery out here, clear your land, and you would mix your soil up to about plough depth, and you would thoroughly mix all your organic matter to a depth of about seven inches and then plant.

Dr. Wright: Of course the important thing is the available nitrogen.

Mr. Rindt: What is the base -- 2/10 percent of?

Mr. Youngberg: You could figure it in pounds per acre. Just figure 2/10 percent of two million pounds.

Mr. Rindt: That is the weight of the soil?

Mr. Youngberg: That is two percent of the weight of all material in the top seven inches of one acre.

Mr. Isaac: You mentioned earlier the nutrient contributed by the annual needle fall of forest trees. Some years back we took a sample of our northwest species and sent it back to Bob Chandler at Cornell, and he ran a nutrient content for us, and we have since run the total amount of that per acre. For example, we found that cedar was high in the production of calcium and nitrogen. The question that plagues me is, does cedar take that much out of the soil first as well as giving that much back, or is there some balance in favor of the soil? Is cedar a good soil conditioner?

Mr. Youngberg: Well, you hear the statement that certain species are soil building species. Take, for instance, sugar maple has often been spoken of as a soil building species as compared to oak. Now you take a stand of sugar maple and a stand of red oak growing practically side by side and analyze the surface layers and litter under the oak and under the maple. You will find generally that the maple will be higher in calcium than the oak. It will be generally higher in the other nutrients also. It is generally thought they have a better ability to extract those nutrients from the soil.

Mr. Youngberg: On some of the soils back in the Lake States or in the corn belt where you get either a residual limestone or calcarius drift, these trees go right down and take it right out of the lower layers and deposit it right on top of the soils, and actually your soils in the prairie region are less acid because the grass roots don't get down into those calcarius driftsof residual limestone. Some species are able to extract it from the soil more readily than others, and apparently cedar is able to extract calcium more easily than Douglas-fir and some of the others. It can only take what is there.

Mr. Augenstein: I have a question right in the same line. Will a forest maintain its nutrients in the soil? What is going to happen to forests eventually? We take the wood off -- of course, you get your litter back.

Mr. Youngberg: Well, actually the amount of nutrients that are in the wood over, say, a rotation of a hundred years is practically a drop in the bucket. Maybe I shouldn't say this, but where you burn the slash, you actually are taking away more from the soil than you do by harvesting the crop. It depends a lot on the condition of the soil and the amount, how bad the organic material is depleted by the slash fires and so on. I have seen some slash burned areas down in Oregon on some of the Weyerhaeuser Timber Company tree farms where they burn the slash after they have had about five inches of rain, and they got rid of the surface debris, but the duff layer was relatively untouched and there the organic matter was high.

Chairman Webster: And they didn't hurt their soil too bad?

Mr. Youngberg: That's right, I would say it was uninjured.

Mr. Isaac: A little practical check of forest depleted soil or not is up on the Simpson Shaffer area on the Wynooche, where they run the railroad right-of-way through an old homestead. The homesteader cleared the area some 25 or 30 years ago, and where they cut, a lot of these small firs had grown up there after he had cleared. They were about 25 or 30 years old, and just going through there one day I stopped and measured a bunch of those 25-year-old trees, and then I went where they cut through the virgin stand and they were cutting this 600-year-old stuff there, some of it a little over 600 years old, and I measured the first 25 years of growth and a lot of those 600-year-old stumps right in the same general terrain. The ring patterns were almost identical, so that 600 years of growth had really maintained that soil. It hadn't depleted it or built it up or anything else.

Mr. Youngberg: I think there is a lot depends upon the land use, what kind of treatment the land gets after it is cleared and so on. You take an experience that they had back in New York where they have taken lands that were cleared and farmed for about a hundred years and then they were just completely worn out, and they got definite response to applications of potash fertilizer and an increase in growth, both diameter and height growth, but just the removal of the timber itself isn't depleting the forest soil.

Mr. Adams: Of course, the kind of soil would be quite different. That Wynooche stuff would be heavy loam. We have quite a problem in one of our nurseries in soil tilth. There is an extremely heavy clay. The first year we worked the soil about 6 inches deep, I guess, without any preparation at all, and the roots of the fir went down about 4 inches and then just spread out. And we are trying to build it up now. We have had two cover crops and this last fall we put on from 4 to 6 inches of sawdust and worked it in well, and we probably should have left that for a year or so before we did anything, but I thought we would try some seedlings on it, and we still had an extremely heavy crust on that soil. Now, are we going to continue to have that trouble? I mean even after the sawdust decomposes and we keep working it in, are we still going to have trouble with that clay?

Mr. Youngberg: Well, I wish I could say no, but it is just one of those things that needs more investigation, more experience. I wouldn't say yes or no. It is just a hard nut to crack.

Mr. Adams: The water doesn't permeate very well.

Mr. Youngberg: Of course where you get water that doesn't infiltrate into the soil very readily and then evaporates back up, you get more crusting than you do when you get good infiltration.

Mr. Adams: Is there a mulch we could use, do you think, on that? Of course, by adding mulches, you are depleting your nitrogen.

Mr. Youngberg: Well, if you add too much.

Mr. Taylor: There is one question that hasn't been brought up here, probably because it is of little or no importance where you have plenty of moisture, but it is a major problem in the drier areas of the southwest, what to do about land that is excessively high in total salt content, whether alkaline salts or natural salts. Down around Salinas it is not alkaline. It is usually around 7 or 7.2 pH, but it is very high in total salts. Is there anything at all to do about it?

Mr. Youngberg: I haven't had too much experience with any of those soils that are high in salts like that. They have, of course, soils they have reclaimed by gypsum treatments.

Mr. Taylor: Black alkalis?

Mr. Youngberg: Yes.

Mr. Taylor: But if you just convert from one soil to another, you still have a high salt content.

Mr. Youngberg: Yes, but generally it is replaced with a calcium rather than sodium.

Mr. Taylor: Yes.

Mr. Youngberg: But on soils that are alkaline or more slightly alkaline than neutral, it is just hard to say. I have no experience about that.

Mr. Knight: Regarding saline conditions, we have a nursery up in the interior that we are working on where we have a similar problem. The soil averages about pH 7; it was down to around 9 in the sub-surface layers to a depth of about 36 inches, something like that, and the general practice -- I get this from most of the western states where they have had saline soil conditions -- is to over-water or leach the soil nutrients off. Some of them are sodium and that causes the black alkali, or in our case, it is calcium, and that is generally termed, I think, kind of a white alkali, and the pH isn't quite as high, but the general practice is to leach out the soils with good drainage and then apply certain nutrients that you think possibly would get washed out with the toxic element that you are desiring to get rid of, and I think they have used sulphur very successfully. The fact that the sulphur organisms, using the sulphur as an energy source produced large amounts of sulphuric acid, and also others are ammonium sulphate, iron sulphate and aluminum sulphate, and I think that is about the only ones they have tried out. And then regarding the clay question, I think even if you have a heavy clay and are able to work the top soil into good tilth, the top 6 inches, you still have to provide adequate drainage below if you are going to set up more optimum conditions for growth, and just by adding the organic matter, sawdust or whatever it is, I think you still have to loosen up the sub-soil before these conditions can be set up.

Mr. Youngberg: One thing in connection with that excessive leaching you have to be careful with is oftentimes where you have conditions of high pH, you also have a high concentration of salts in your water, and the problem of a practically pure water to leach those soils is generally a limiting factor, not always, but in many cases.

Mr. Corson: I wanted to ask what he meant by physiological grades. You mentioned physiological grades.

Mr. Youngberg: Well, that is one of those terms that was coined, I believe, down south. Wakeley, I think, is the one that has coined the expression. It is actually the difference in the physiological internal makeup in the plants that is not necessarily discernible and the gross physiological features. It is just a difference that has been brought about by some soil factor or some other treatment that they have gotten. The physical processes have just been different.

Mr. Haddock: Those are what he means, I think.

Mr. Youngberg: He has a bulletin out on physiological grades of southern pine.

Mr. Adams: You mentioned applying fertilizers with a cover crop. Do you mean at the time of sowing?

Mr. Youngberg: Yes, just like you do if you were growing alfalfa or something for forage, or anything like that. You apply your fertilizer prior to your seeding and then incorporate it actually in the plant tissue, and then plough it under and you have it there in more or less organic form.

Mr. Adams: Well then, after you plough it under, are you supposed to let your ground lay fallow for a period of time to build back your nitrogen, because in ploughing that under, in decomposition, won't that deplete your nitrogen?

Mr. Youngberg: It depends a lot on when it is ploughed under. If you let it mature and it gets a high nitrogen ratio, you will have a certain amount of nitrogen tied up; if you plough it under when it is fairly young and succulent, you wouldn't have the wide carbon nitrogen ratio.

Mr. Taylor: The big Seabrook Farms back east have done quite a bit of experimenting in recent years in applying fertilizer to the crops that are intended to use it or applied to the cover crop previously, and they have a very favorable showing in getting better and more actual use out of the fertilizer if they applied it to the previous crop and converted over to the organic form. It is much more uniform if you apply it to the crop ahead. You have a much more uniform distribution.

Mr. Chapin: I think probably you find most of your nutrient solutions where you grow things in water culture in the greenhouse for yeast purposes. Generally your nutrient solutions are designed so you have the necessary elements present, but also you have a balance between your cation and anion in your solution. Actually, that is approximately what is happening when you put those fertilizers in the soil, incorporate them into the organic material, and then their biological and chemical processes go on in the soil and you form organic matter. You get a fairly good balance between those cation and anion, if you choose to call them that, and you have a more natural environment for the growth of seedlings.

Mr. Isaac: One question about applying fertilizer to the crop of the previous year in a locality of extremely heavy rainfall, if you apply it to the crop the previous year, aren't you likely to lose some of it before the new crop gets to take it up?

Mr. Youngberg: You will lose a certain amount of potash because potash salts in plant tissue are water soluble. You can take dry plant tissue and leach it with water and get out practically all the potash there is in plant tissue. On the other hand, the other constituents, like nitrogen and phosphorus and so on, you don't lose any amount. That is one reason why sometimes even with the system of cover crops, you will find that potash will be in short supply.

Mr. Isaac: It is quite a difference when you have a hundred inches of rainfall as against 15 or 20.

Mr. Youngberg: That's right.

Mr. McDaniel: We are trying to work out a system down in our nursery. We have swung over to white clover and a fescue grass mixed in with it, and we had a crop this year that would average about 4 feet, with root crowns around an inch and a half in diameter, but then we get a weed problem there also the first year in this cover crop. Now, the

Mr. McDaniel: (cont'd) question is would it be advisable to swing to annual crops, that is, your grasses? We have on the nursery now a Sudan grass which is between 5 and 6 feet high and is pollinating, and it is being ploughed under, I hope, this week. Now I might say, when we plough that under, we will knock that down with a big tandem roller. We will add 150 pounds of ammonium sulphate. We add our nitrogen;otherwise, the decomposing crop would take it out of the soil. Now, this fall, after that is worked down, we are planting winter wheat on that. Of course, we go on our two-year program, two years to cover crops. We also hope that after this winter wheat goes under, we will also have a little nitrogen added to it, and I am questioning this, whether it would be reasonable to add that extra 100 or 150 pounds of nitrogen on this wheat crop which we know will get from 5 to 6 feet in a green stage when it starts pollinating, and we will let that stay for 2 or 3 weeks laying under the ground, ploughed under and well watered. Now, is it advisable to come back on top of that in 2 or 3 weeks and plant a crop of buckwheat which is a good weed controller on this summer fallow land? It controls weeds pretty good, and then we merely disc that under because it cuts up good, and of course roll it afterwards. Would it be advisable to go to that type of rotation or maintain that clover, which of course produces your heavy type roots, aerates your soil and also builds a water reservoir? That is our alternative program. Now, which one do you think would prove to be the best? What we are trying to get away from is weed control.

Mr. Youngberg: I will have to come down and see you on that one.

Mr. McDaniel: While I am on my feet, I don't want to talk too much, but we have found out and we are blessed, as most of you fellows saw, with heavy soil. We use our ripper as our old friend over here in Shasta said -- he had used the same thing. We used a soil ripper and we go down 16 to 18 inches deep and we really tear that soil to pieces. On the back of the ripper we intend to put about a 4-inch mole that carries underneath the ground, and that ploughs a little tunnel under there about 8 to 16 inches deep, and provides a better drainage and improves the soil.

Mr. Youngberg: That might be an answer to your question.

Mr. Adams: I want to ask, in commercial soil testing kits -- are they worth anything?

Mr. Youngberg: Well, it depends a lot on the conditions. You will find that under certain soil conditions. Certain soil testing methods are better than others, and it is just one of those things. I don't think there is any one soil testing kit that will be applicable to all soil conditions. You know that acid soils react differently to certain tests than alkaline soils, so it depends a lot on your condition.

Mr. Taylor: Isn't it about 5 percent testing and 95 percent interpretation?

Mr. Youngberg: Well, that is true to a certain extent, but of course your degree of accuracy with certain methods of testing is important. You can take two different methods and in one case get 50 percent per acre of available K and on another you might get 10 percent. Now which one is right? I will say this, in the Douglas-fir region generally the True log method of quick testing has been adopted as a standard. This is more or less a tentative arrangement. If we find some other methods are better, or quicker testing, we will use them. At present that is the method. I think it is one of the better soil testing kits that is out. I think probably one of the best features of it is the method of comparing your standards, your color standards and so on. It is much more accurate than a lot of them. Where you just have colors on a chart and then get a solution and compare them, there is a lot of leeway, whereas if you have a light background and put a solution in a tube down next to the standards, and have a light source behind it, you get quite a lot more accuracy.

Chairman Webster: I think, to help answer that question, the best way to handle your soil testing is to get the best man you can get to do it, and don't monkey around with any other ways, because I have found out since Chet came out here that he has done us more good by telling us what we have in our nursery and what we need than we were able to find out from limited experience. Good soil men just apparently aren't very available, because we haven't had too good luck in the past.

Mr. Lanquist: I am kind of confused about Mac's cover crops here. Anyway, we have been using all kinds of cover crops in Mt. Shasta. We used soy beans;that wasn't so good. It falls off, but it gave us a lot of tonnage if we could keep it from freezing out. Then we used vetch, but we didn't get so much tonnage out of it; so one of the boys from the Lake States sent us some lupine and I don't know if any of you fellows have tried it, but we tried the lupine at Mt. Shasta Nursery and it really looked promising. It will also shade out your weeds, Mac, because it really shades the ground, and I don't remember the tonnage but it was tremendous - 4 to 5 per acre.

Chairman Webster: Do you know which lupine it is?

Mr. Taylor: It is the southern one, isn't it?

Mr. Lanquist: There are two kinds of lupine, the blue and the white, that is all I know.

Chairman Webster: Well, will you send the information to me and we will see that it is incorporated in the minutes so it will be available to the group.

Mr. Lanquist: Now, there was another question I would like to ask about this chart that you have up there, Chet. Does that mean the soil's fertility out in the forests?

Mr. Youngberg: Yes.

Mr. Lanquist: On a Douglas-fir stand?

Mr. Youngberg: That's right.

Mr. Languist: All right. So now if we maintain that soil fertility in our nurseries, should that be an ideal set-up, or how does that work?

Mr. Youngberg: Well, I could say that more nearly approaches the optimum growth conditions that you find in nature, as it were, under natural conditions, and you put those over into the nursery and you are more nearly approaching the conditions as far as the soil fertility status is concerned that they would find under normal growing conditions. I think that this fairly closely approaches, with the exception of phosphorus, the conditions at Capitol State Forest Nursery of the State of Washington and their trees aren't excessive in size by any means. As far as size is concerned, a lot depends upon water, and where you get ample water supply, be it by sub-irrigation or overhead irrigation, you are going to produce large seedlings, unless you get practically sterile soil.

Mr. McDaniel: I would like to make a correction. I said in my little dissertation here - this is not alta fescue, it is English rye, which is a biennial, the same as white sweet clover which we are using, because alta will go into seed the first year and this other won't. You can grow more tons with these three crops of two grasses, sudan grass, and then possibly instead of wheat, Abruzzi rye which will grow tremendous heights, up to 7 and 8 feet.

Mr. Chapin: I was kind of disappointed in having him change his mind here, from his alta fescue over to rye grass, because we use alta fescue, quite a lot of it. Of course, you know our operations are partially grass production too, so it works into a beautiful rotation with our grass seed production and our tree production.

Mr. McDaniel: But it grows to seed the first year, and your English rye is biennial.

Mr. Chapin: No, we do not have too much trouble and our records have shown about 7 to 8 tons of root material in the top 6 inches, where alta was down around 5.

Mr. McDaniel: Of course, that would be very little with the clover just to give the protection and fill in the gaps.

Mr. Chapin: And then we followed through, like you, with the abruzzi rye, and I want to add one word of caution on this lupine. We have tried it and I believe it is not hardy in Washington and I doubt if it would be in British Columbia. I think it would work fine in California.

Mr. Augenstein: Ours has stood three hard frosts this summer.

Mr. Rindt: I was wondering if anybody has paid any attention to the effect of these cover crops on damping off, root rot, and so on. I believe Ernie has done some work and has done some reading on that subject and has some evidence to the effect that you can either control some of those damaging organisms with the type of cover that you have, or possibly on the other hand, build them up to a danger point.

Chairman Webster: I think you have a good point there, Charlie. One word of caution: if you have a good system of crop rotation that is working out satisfactorily, you had better stay with it, because if you change to something you think may be better, you may be jumping from the frying pan into the fire.

Mr. Adams: I imagine it would depend on your soils quite a bit, but is a 2-year cover crop rotation system necessary?

Mr. Youngberg: Well, you use a 1-year, don't you?

Chairman Webster: No, we use a 2-year, and we feel it is definitely necessary.

Mr. Chapin: We do too, and we are on the heavy soil similar to what he is talking about, heavy clay soil, and we found 2 years absolutely essential and 3 better.

Mr. Youngberg: Some nurseries I know back in the Lake States use 1 year and some 2 years. I have never seen any data on comparative values of one against the other, but it depends a lot on the local conditions, and space quite often will be a limiting factor.

Mr. Adams: In our nursery, I get 2 cover crops in 1 year.

Mr. Youngberg: Well, you have about a 365-day growing season.

Chairman Webster: We have really two subjects in one coming up now, fellows, the Use of Chemical Dyes for Quick Germination Tests, and Recent Developments in Determining Tree Cone Maturity. If we can find a good method of quick germination tests, it will be very helpful to us. These two subjects will be presented by Mike Finnis.

Mr. Finnis: I think the logical way to start is to take the second question first, because you have to collect your cones before you can do anything with them. I should also emphasize that this applies to Douglas-fir, and also to this part of British Columbia, and any dates I might mention will most probably have no bearing on any other parts of the country.

RECENT DEVELOPMENTS IN DETERMINING TREE CONE MATURITY

by

G. M. Finnis

* *

It is not necessary to emphasize to you gentlemen the value and importance of fir seed since it is the basis of the livelihood of us all. Here, in southwest British Columbia we are anxiously waiting for the next good cone crop. In 1945 we had a bumper crop and in 1950 a good crop in some areas. Fir seed is now worth about $ a pound and when the opportunity is given to us, we must gather all we can. That means we must start cone collections as soon as the seeds are ripe so that the maximum may be collected before the cones start opening and shedding their seed. Conversely collecting immature seeds is just a waste of time and money. The problem is simply "when to start cone collecting?"